Floods of a warmer world: learning from the last interglacial

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Abstract

In a warmer world, the hydrological cycle will change in intensity and in its geographic behaviour. This, in turn, will change patterns of river flood and the risk associated with them. The Last Interglacial (LIG; 125,000 years ago) is the most recent instance of climate warmer than today - especially in the high northern latitudes-, sea level was higher, ice sheets were smaller and monsoons were stronger. We use daily output from multi-century LIG simulations of an ensemble of paleoclimate models, and study how global precipitation patterns and extremes deviate from the preindustrial climate. We validate these results by comparing them with the first compilation, to our knowledge, of global LIG precipitation patterns. Successively, we use the daily temperature and precipitation from the paleoclimate models to drive two global hydrological models (PCR-GLOBWB and CWATM), and simulate river discharges at 5-30' resolution. With this, we force a hydrodynamic model, CaMa-Flood, and produce floods maps for different return periods. At the end of this model cascade, we look into what would happen if a climate similar to the LIG were to materialize in the coming decades: we combine the flood maps with maps of exposure through vulnerability relationships, and to calculate the risk that floods may pose to future people and assets.

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I – We already had a warmer climate

Changes in the hydrological cycle have large consequences for society[1]. In particular, precipitation extremes and floods may get worse in a warmer climate. Besides relying on global climate models forced with greenhouse scenarios, we may look at past climates to understand how the hydrological cycle may rearrange under warmer conditions. **The Last Interglacial[2] (LIG, ~127,000 years ago)** may be the best candidate for this. Here we analyze the LIG precipitation and its extremes through an ensemble of climate models and through proxies. Then we will simulate LIG fluvial floods and their impacts.

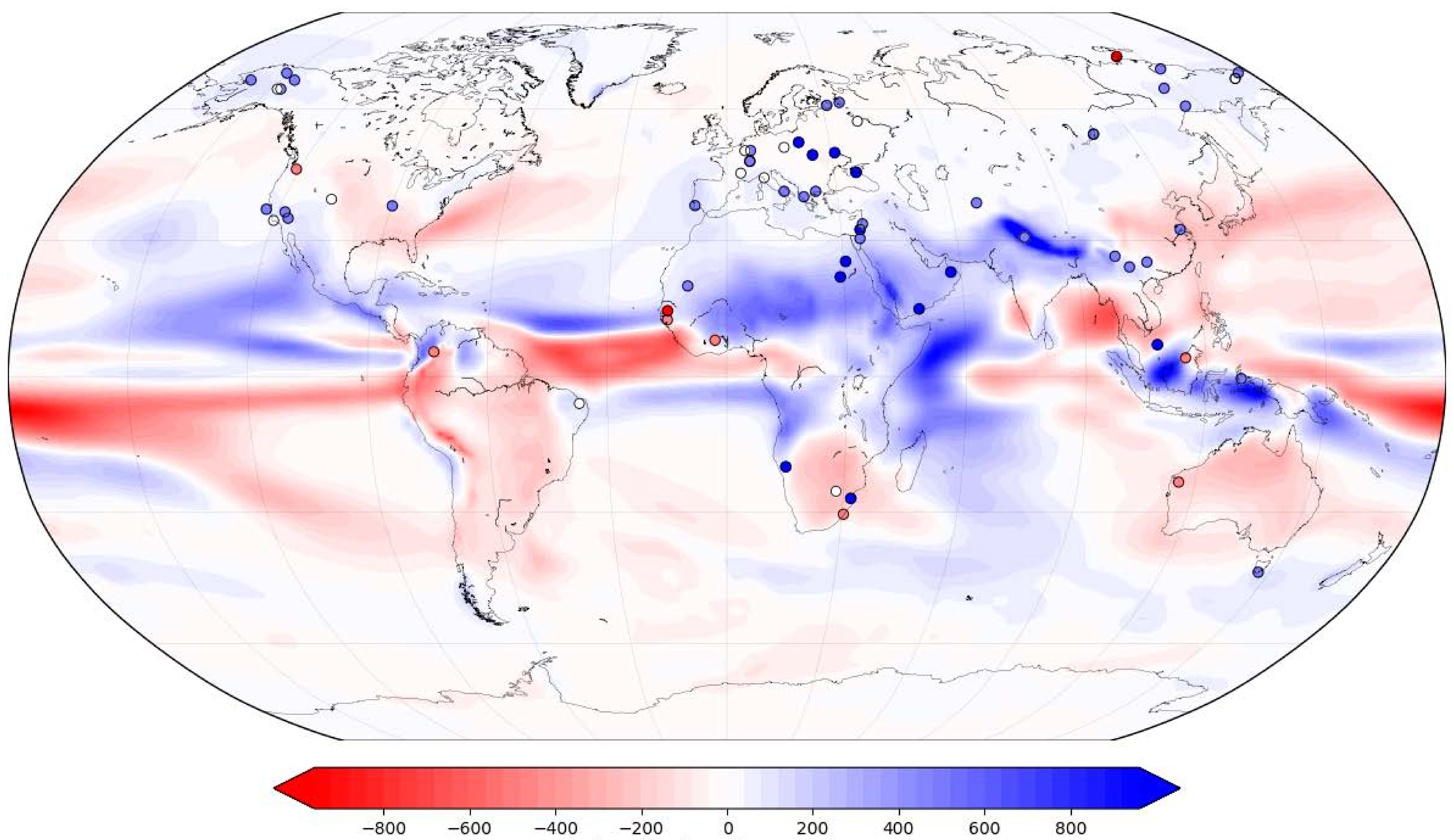

Fig. 1: Annual precipitation anomaly between Last Interglacial and preindustrial/ present, from models CESM1.2 and NorESM (contours; mm/year) and from proxies (circles; qualitative scale). Blue = wetter Last Interglacial

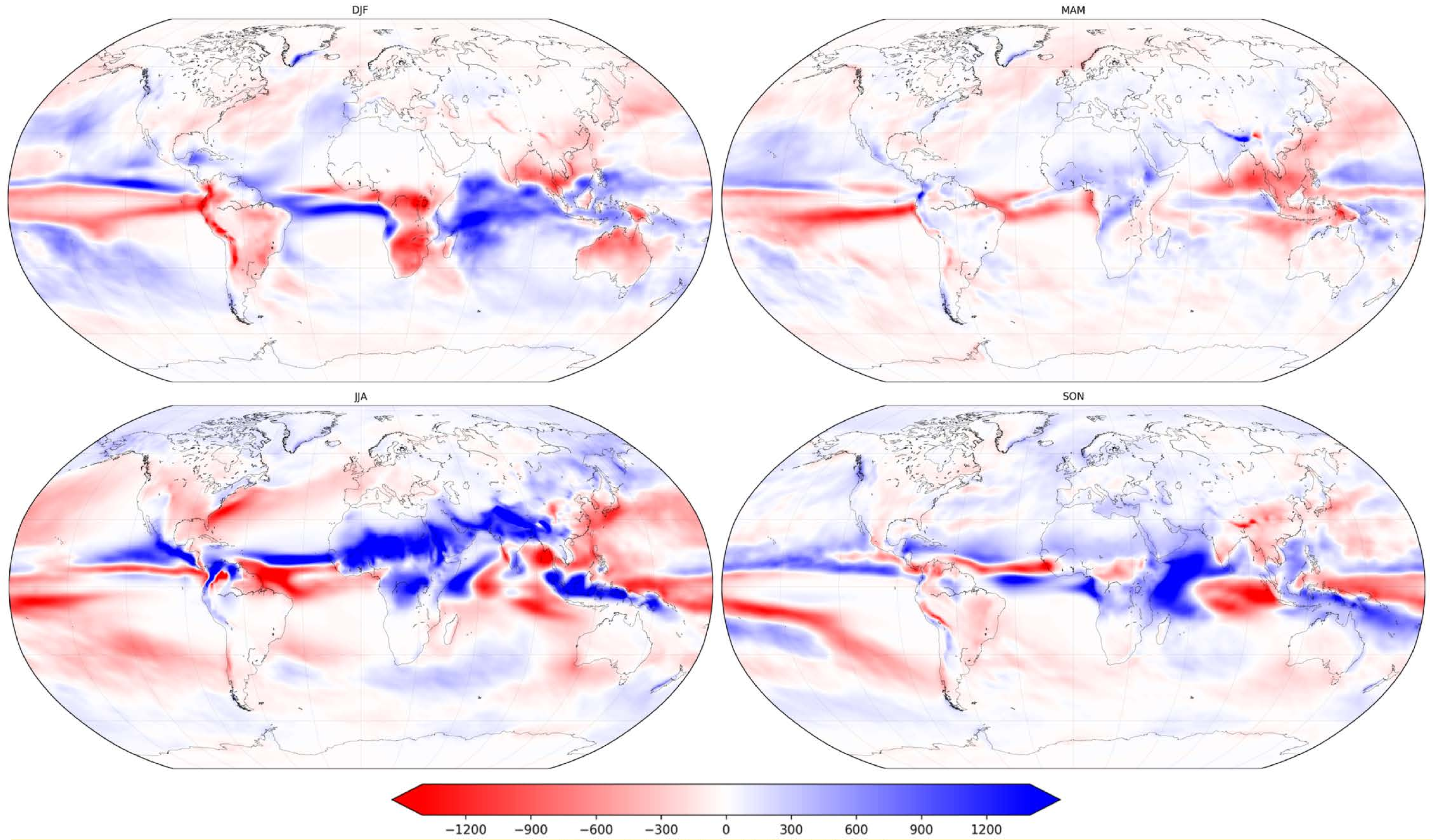

Fig. 2: Seasonal precipitation anomaly between Last Interglacial and preindustrial (mm/year), showing only CESM1.2. Blue = wetter Last Interglacial

II – Model vs proxy precipitation – fig. 1 - 2

We compiled the first global dataset of proxies for LIG precipitation. So far it contains 85 entries, with qualitative or quantitative precipitation anomaly between LIG and present/preindustrial. The CESM1.2 and NorESM **inter-model average agrees with ~60% of the proxies**, mostly in north Africa, Middle-East, central Asia, northeast Asia, northwest America and Australia. Seasonal precipitation anomalies from CESM1.2 show **much stronger LIG northern hemisphere summer monsoons** - North Africa, North America, Indian and Asian-Australian monsoon, and **diminished LIG Southern monsoons** - west of South American, South African, Australian monsoon, with regional variations.

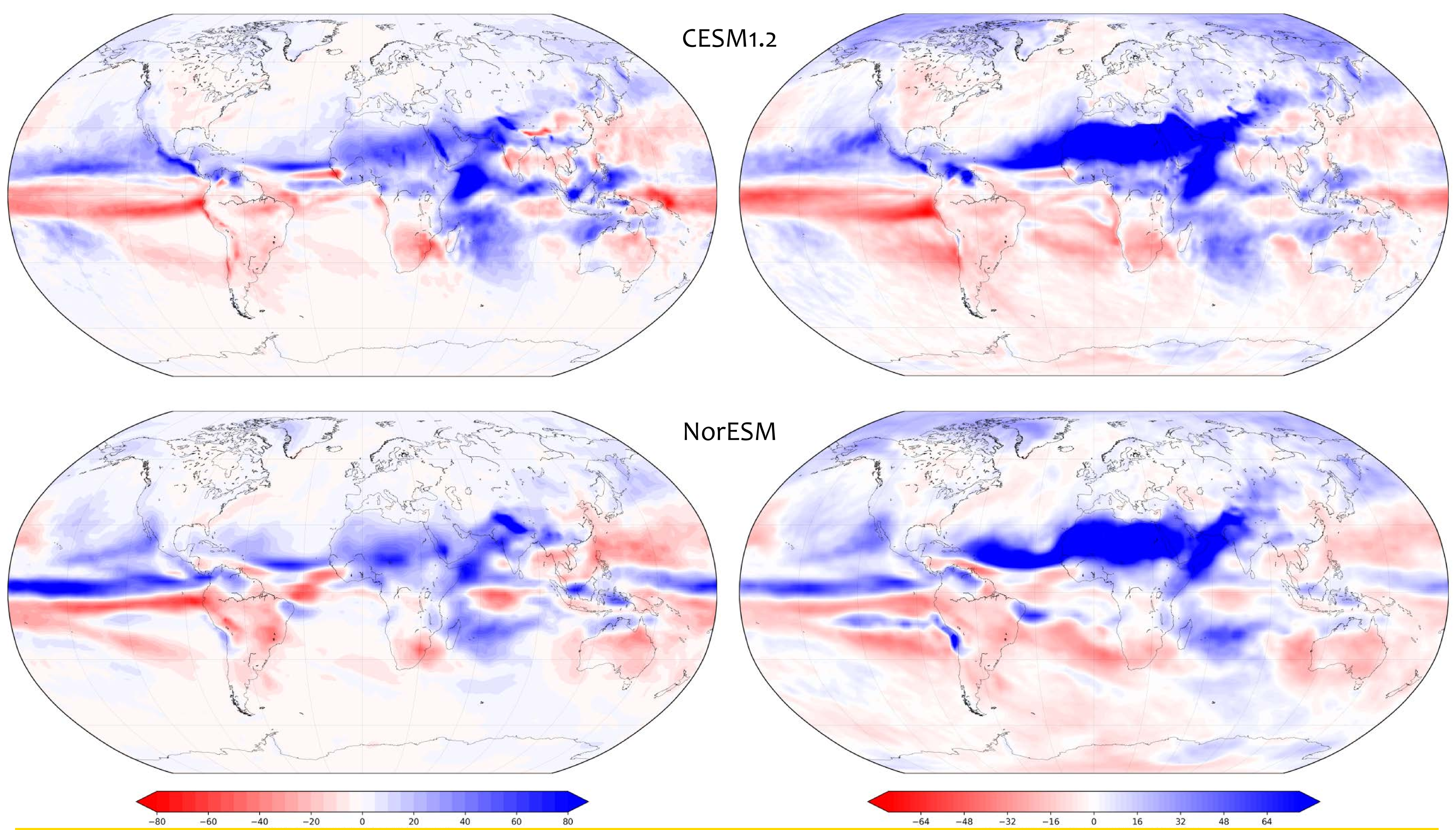

Fig. 3: Annual precipitation index RX5day anomaly. Left: mm in 5 days; right: as % change. Blue = more extreme precipitation in the Last Interglacial

III – Precipitation extremes – fig. 3

Annual precipitation extremes (5-day max precipitation: RX5day index) in the LIG are stronger in the whole north Africa and Middle-East, northwest India, in areas of east Asia and Indonesia, in western central and north America, northern South America and western Iberia.

IV – Further work – fig. 4

1) Include daily LIG **results from other PMIP4 models** - CESM2, EC-EARTH3.2, IPSL-CM6, MPI-ESM 1.2.01, NUIST-CSM and potentially more.

2) Input daily variables from the paleo climate models in a **hydrological model** (PRC-GLOBWB, CWATM[3]), to obtain river discharges, and in turn in a **hydrodynamic model** (CaMa-Flood[4]) to simulate river floods at 30'' resolution.

3) Calculate **river flood risk**, as if the past climate were to replicate in the future. With the GLOFRIS framework[5], we will project flood impacts based on exposure of population and assets from socioeconomic scenarios.

4) Will also study changes in **storm surge and coastal flooding**, with the GTSM model[6-7]; plus we will look at changing patterns of meteorological **drought**.

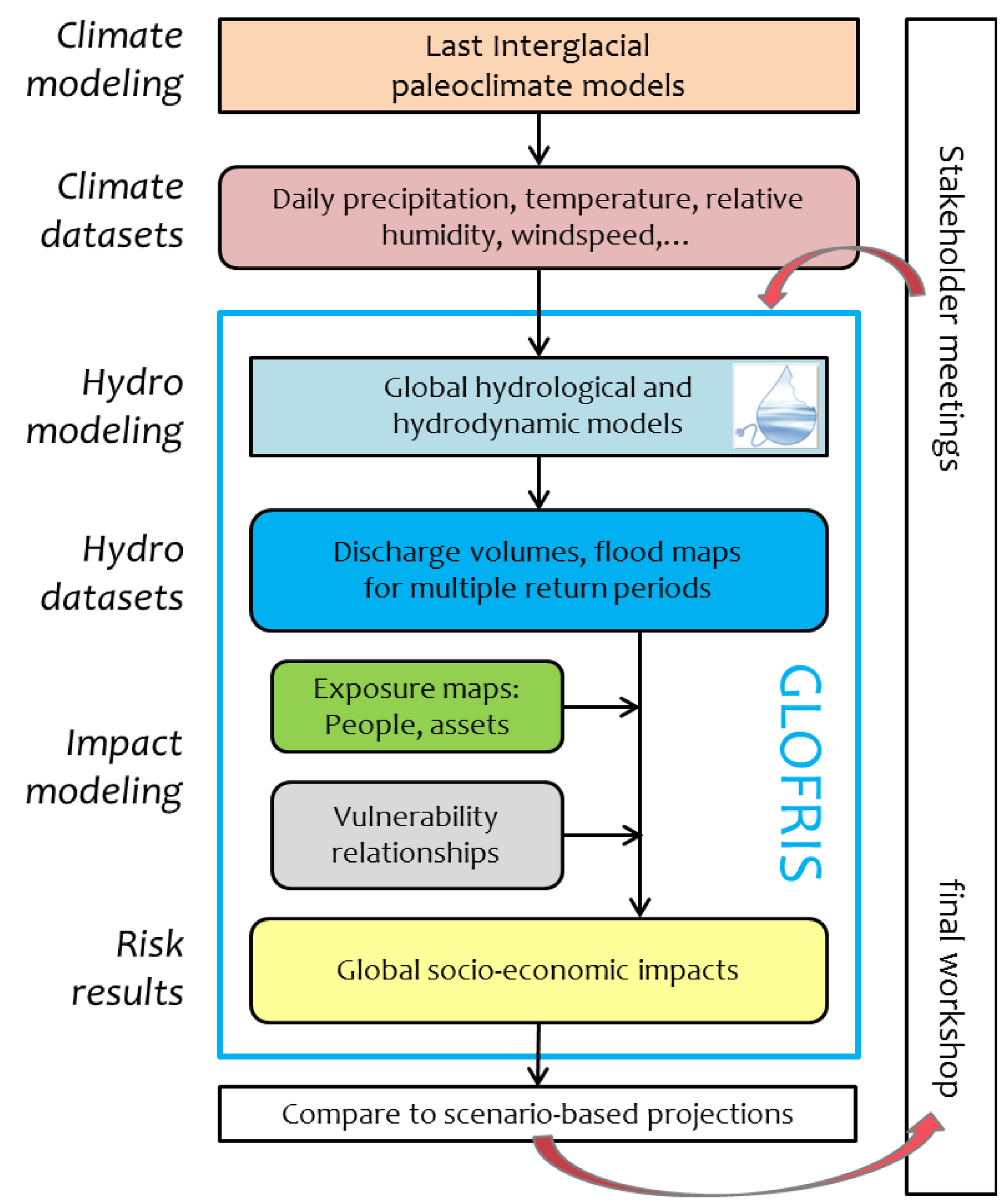

Fig. 4: Structure of the whole project

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